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ABSTRACT

Seventy-six subjects were exposed to single impulse noises produced by two small shoulder-fired rockets, and TTS_2 was compared with the CHABA limits. The single impulse, 95% protection, and grazing incidence correction factors of the CHABA damage-risk criterion were validated. Grazing-incidence shock waves produced comparable results when they arrived at the ear from the front and from the rear.

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Validation of the Single-Impulse Correction Factor of the CHABA Impulse-Noise Damage-Risk Criterion

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Seventy-six subjects were exposed to single impulse noises produced by two small shoulder-fired rockets, and TTS_2 was compared with the CHABA limits. The single impulse, 95% protection, and grazing incidence correction factors of the CHABA damage-risk criterion were validated. Grazing-incidence shock waves produced comparable results when they arrived at the ear from the front and from the rear.

THE MOST COMPREHENSIVE IMPULSE-NOISE DAMAGE-RISK CRITERION (DRC) developed to date is that which was prepared by Working Group 57 of the NAS–NRC Committee on Hearing, Bioacoustics, and Biomechanics (CHABA, 1968). This DRC consists of peak pressure level and duration limits which assume exposure to 100 impulses/day, arriving at the ear at normal incidence, and protection of 95% of exposed ears from excessive $TTS_{2\,min}$ (temporary threshold shift). Allowable limits of TTS_2 (in 5% of exposed ears) are: 10 dB at or below 1 kHz; 15 dB at 2 kHz; and 20 dB at or above 3 kHz. Correction factors for number of impulses/day, and for ear orientation, permit a family of exposure limit curves to be constructed as illustrated in Fig. 1.

As stated in the CHABA DRC, the correction factor for number of impulses/day is tentative and based on little empirical evidence. Therefore, this investigation was conducted with three purposes in mind:

(1) To test the predictive accuracy of the single-impulse correction factor of the CHABA impulse-noise DRC.
(2) To validate the grazing-incidence correction factor.
(3) To investigate whether impulses arriving at grazing incidence from the front or rear of the head produced different results.

These studies were conducted with two small shoulder-fired rockets, the M72 LAW and the M20A1 3.5-in. rocket.

I. Method

Subjects: Army enlisted men served as subjects (Ss) for these experiments. All 76 Ss were ears–nose–throat (ENT) negative and had hearing levels within 15 dB of ANSI-1951 audiometric zero at 0.5–6 kHz. The Ss were trained to give reliable thresholds with Rudmose ARJ-4 automatic audiometers (pulsed tone) prior to exposure.

Noise Sources and Exposures: The study was conducted in two phases. Phase I consisted of exposing the Ss to both rockets at the peak pressure level and B (envelope) duration allowed by the DRC, viz., 161 dB at 12.5 msec for the M72, and 159 dB at 33 msec for the M20A1. These permissible levels include a +5-dB correction for grazing incidence, and a +10-dB correction for the single impulse exposure condition. In Phase II, comparing rear versus front grazing exposure, only the M72 was used, again under conditions which met the DRC. For all tests, the daily exposure was to a single impulse. A chin rest was provided at each exposure site to maintain constant ear position and orientation.

Procedure: Ss were tested two at a time at locations on each side of the weapon which were acoustically similar. Preexposure audiograms were followed by exposure to the noise of one rocket firing. In Phase I, 43 Ss were exposed to M72 and M20A1 rocket noises with their backs to the rocket so the shock wave arrived at grazing incidence from the rear (the usual case with small shoulder-fired rocket launchers). In Phase II, 33 Ss were tested, first with their backs toward the M72 rocket and later facing the rocket. The postexposure hearing test was started 2 min later. Pre- and postexposure audiograms were compared, and TTS measures at each frequency were converted backward in time to TTS_2 by using the method of Kryter (1963).

II. Results and Discussion

Table I summarizes the TTS_2 data of Phase I as they apply to the question of the validity of the single-impulse correction factor. For the M72 LAW rocket noise, 7% of exposed ears demonstrated TTS_2 in excess of the CHABA limit at 6 kHz, a result which is slightly less conservative than the criterion. For the M20A1 rocket exposure, about 4% of the ears demonstrated excessive TTS_2 at 0.5, 1, and 6 kHz. These data are slightly more conservative than the criterion. It may also be inferred from these data that the 5-dB grazing-incidence correction factor is accurate.

Table II presents TTS_2 data from Phase II which bear on the question of the differential effects of rear versus front grazing-incidence impulses. For the grazing-rear exposure, about 5% of exposed ears exceeded CHABA-limit TTS_2 at 0.5 kHz, which is the result predicted by the DRC. For the grazing-front exposure, about 3% of ears demonstrated excessive TTS_2 at the same frequency. The results for these two exposure conditions are considered to be essentially identical.

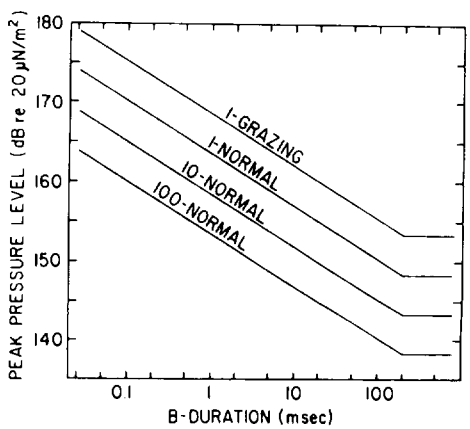

FIG. 1. Family of peak pressure level versus duration curves derived from provisions of CHABA impulse-noise DRC. Parameters are number of impulses and ear orientation. Top curve was used in these studies to select CHABA-limit exposure conditions.

TABLE I. TTS_2 (in decibels) at CHABA-limit conditions of M72 and M20A1 rockets. Grazing incidence impulses from rear. $N = 86$ ears.

Test frequency (Hz)	CHABA limit	M72 LAW rocket				M20A1 rocket			
		Median	Min.	Max.	Percent ears exceeding CHABA limit TTS_2	Median	Min.	Max.	Percent ears exceeding CHABA limit TTS_2
500	10	0	−15	15	2.2	0	−10	15	3.6
1000	10	0	−10	15	1.1	0	−10	15	3.6
2000	15	0	−10	15	0	0	−10	10	0
3000	20	0	−10	15	0	0	−15	15	0
4000	20	0	−10	20	0	0	−10	15	0
6000	20	0	−20	40	7.0	0	−10	30	3.6

TABLE II. TTS_2 (in decibels) at CHABA-limit conditions of M72 rockets for grazing-incidence exposures from the rear and front. $N = 60$ ears.

Test frequency (Hz)	CHABA limit	Grazing—rear				Grazing—front			
		Median	Min.	Max.	Percent ears exceeding CHABA limit TTS_2	Median	Min.	Max.	Percent ears exceeding CHABA limit TTS_2
500	10	0	−20	20	4.5	0	−15	15	3.3
1000	10	0	−15	15	3.3	0	−15	10	0
2000	15	0	−15	15	0	0	−15	15	0
3000	20	0	−10	20	0	0	−15	15	0
4000	20	0	−10	15	0	0	−15	20	0
6000	20	0	−25	20	0	0	−20	25	1.7

Three conclusions appear to be warranted on the basis of these results:

(1) The single-impulse correction factor of the CHABA impulse-noise DRC has been validated, at least for impulses having B durations of 12.5 and 33 msec.

(2) By implication, the 95% protection, and grazing incidence, correction factors have also been validated.

(3) Grazing-incidence shock waves appear to produce comparable results when they arrive at the ear from the rear and from the front.

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KRYTER, K. D. (1963). "Steady-State Noise and Impairment of Hearing," J. Acoust. Soc. Amer. 35, 1515–1525.